stantial contributions to the global science and technology enterprise. (See chapter 2.)

Significance of Developing Countries

The Steelman report pointed to India as a country where progress was being made in the construction of new scientific research laboratories and in the training of first-rate researchers (Steelman 1947, vol. I, 41). It predicted that similar developments could be anticipated in China and in Latin America.

Today, the developed countries (primarily the United States and Canada, Western Europe, and Japan) still account for by far the largest fraction of the world's R&D expenditures, with the United States, Japan, Germany, France, and the United Kingdom expending more than 2 percent of GDP for these purposes. By contrast, the R&D expenditures of China, India, and Brazil, for example, are estimated to be somewhat less than 1 percent of their GDPs. Despite their relatively modest R&D investments, all three countries have produced world-class scientists and engineers and have developed impressive, competitive capabilities in several important areas. Many scientists and engineers from the United States and other developed countries have enjoyed cooperative working relations with colleagues from these and other developing countries for several years. (See chapters 2, 4, 6, and 7.)

Public Attitudes and Understanding of Science and Technology

Although the analysis of mathematics and science education by AAAS included in *Science and Public Policy* dealt primarily with the production of professional scientists and engineers, a section entitled "Science and General Culture" also emphasized the importance of science education for nonspecialists. It suggested that "maintenance of the crucially necessary supply of research talent, and integration of the sciences into a sound ethical structure of society without which civilization cannot survive, are both dependent upon adequate representation of science in our educational system"(Steelman 1947, vol. IV, 113).

Today, both *Science in the National Interest* and *Unlocking Our Future* emphasized the importance of public attitudes and understanding both to the vitality of the science and engineering enterprise and to the Nation, particularly since understanding many significant national issues requires some familiarity with science and technology. It has also been recognized that the level of public understanding of adults is strongly correlated with the adequacy of the science and mathematics education they receive at the primary and secondary school levels.[63] Bipartisan support is evidenced by the consistently high level of NSF's annual education and human resources appropriations, $689 million in FY 1999. (See chapter 8.)

[63]The widespread consensus about the importance of science and mathematics education at the primary, secondary, and undergraduate levels is suggested by the fact that NSF's annual budget for education and human resource development currently exceeds $600 million.

Impacts of Information Technology

Had the term "information technology" been in use in the 1940s, it might well have referred to developments in communications technology—namely, radio and perhaps even television—that had been successfully demonstrated immediately before the outbreak of World War II but were not commercialized until a few years later. *Science—The Endless Frontier* did cite radio as one of several technologies whose widespread commercialization occurred after the end of World War I. It did so to suggest, by inference, that new and at that time (1945) unimagined technologies would almost certainly result from the applications of post-World War II research. However, neither the Bush nor the Steelman reports speculated about what those future technologies might be.

But on a personal level, Vannevar Bush foresaw the development of what is now called the digital library. In an article published in the Atlantic Monthly in July 1945 (the same month that *Science—The Endless Frontier* was delivered to President Truman), Bush invited his readers to …

> Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory (Bush 1945b).

Today, information technology, based on a merging of computer and communications technologies, has become ubiquitous. Information technology has had an impact on virtually all sectors of our economy and society, including the conduct of research, as well as on our daily lives. The digital libraries that Bush foresaw more than a half-century ago are becoming a reality, even though based on very different technologies than he envisioned. Nor did he foresee the possibilities that digital libraries separated by great spatial distances could be linked electronically and accessed from other distant locations. (See chapter 9.)

Current Emerging Themes

As discussed in "A Program for the National Science Foundation," the NSB determined during its first year that one of its major responsibilities would be to ensure that the condition of the U.S. (and global) science and technology enterprise would be monitored. Since 1972, its *Indicators* reports have been the most visible manifestation of that determination. The NSB published a strategic plan in November 1998 that emphasized its commitment to *Science and Engineering Indicators* as an instrument for assessing the overall health of the enterprise and for providing a robust basis for decisionmaking in national science and engineering policy, as well as its determination to continually improve this instrument to serve these objectives (NSB 1998c). These reports have also provided the Board with opportunities to point to both emerging themes and to emphasize transmutations in the more traditional themes that began to be evident 50 years ago.

Among the emerging themes that the Board has identified (NSB 1998c) as important in the first decade of the 21st century are:

- globalization of research and education,
- access to and impacts of information technologies,
- environmental research and education,
- knowledge-based economy,
- partnerships and linkages,
- adequacy of the supply of well-trained scientists, engineers, and science teachers,
- education as a key determinant of social and economic progress,
- special significance of K through 12 education,
- public understanding of science and technology, and
- accountability.

Plans to address these themes are laid out in the NSB Strategic Plan (NSB 1998c). Additionally, several of these themes have been addressed by previous NSB Statements and Occasional Papers; for example:

- "Science in the International Setting" (NSB 1982),
- "In Support of Basic Research" (NSB 1993a),
- "Federal Investments in Science and Engineering" (NSB 1995),
- U.S. Science and Engineering in a Changing World (NSB 1996b),
- The Federal Role in Science and Engineering Graduate and Postdoctoral Education (NSB 1997),
- "Failing Our Children: Implications of the Third International Mathematics and Science Study" (NSB 1998a),
- "Industry Trends in Research Support and Links to Public Research" (NSB 1998b), and
- "Revised Interim Report: NSB Environmental Science and Engineering for the 21st Century" (NSB 1999a).

The Board plans to issue additional occasional papers on several of these issues during the next few years.

Selected Bibliography

Baxter, J.P. 1946. *Scientists Against Time.* Boston: Little, Brown.

Blanpied, W.A. 1995. *Impacts of the Early Cold War on the Formulation of U.S. Science Policy: Selected Memoranda of William T. Golden.* Washington, DC: American Association for the Advancement of Science.

———. 1998. "Inventing U.S. Science Policy." *Physics Today* 51, No. 2:34–41.

———. 1999. "The National Science Foundation Class of 1952." Available from <<http://www.nsf.gov/od/lpa/nsf50/classof52.htm>>.

Bush, V. 1945a. *Science—The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research*. Reprinted 1990. Washington, DC: National Science Foundation. [earlier reprints].

———. 1945b. "As We May Think." *The Atlantic Monthly* 176, No. 1:101–8. Available from <<http://ccat.sas.upenn.edu/jod/texts/vannevar. bush.html>>.

Carnegie Commission on Science, Technology, and Government. 1992. *Science and Technology in U.S. International Affairs.* New York: The Carnegie Corporation.

Clinton, W.J. 1998. "Address to the 150th Anniversary AAAS Annual Meeting." In A.H. Teich et al., eds., *AAAS Science and Technology Policy Yearbook 1999.* Washington, DC: American Association for the Advancement of Science: 5–10.

Clinton, W.J., and A. Gore, Jr. 1993. *Technology: The Engine of Economic Growth.* Washington, DC: Office of Science and Technology Policy.

———. 1994. *Science in the National Interest*. Washington, DC: Office of Science and Technology Policy.

Dupree, A.H. 1957. *Science in the Federal Government,* Chapter 19, "Prospect and Retrospect at the Beginning of a New Era." Cambridge, MA: The Belknap Press of Harvard University Press.

Elkana, Y., et al., eds. 1978. *Toward a Metric of Science: The Advent of Science Indicators.* New York: John Wiley and Sons.

England, J.M. 1983. *A Patron for Pure Science: The National Science Foundation's Formative Years, 1945–57*. PB83-193896. Washington, DC: NTIS: 9–112.

Federal Coordinating Council for Science, Engineering, and Technology. 1992. *In the National Interest: the Federal Government and Research-Intensive Universities*. Washington, DC: National Science Foundation.

Golden, W.T. 1995. "Memorandum on Program for the National Science Foundation." In W.A. Blanpied, ed., *Impacts of the Early Cold War on the Formulation of U.S. Science Policy: Selected Memoranda of William T. Golden.* Washington, DC: American Association for the Advancement of Science: 68–71.

Golden, W.T., ed. 1980. *Science Advice to the President.* New York: Pergamon Press.

Holton, G., and W.A. Blanpied. 1976. *Science and Its Publics: The Changing Relationship*. Dordrecht, Holland: D. Reidel.

Huttner, S. 1999. "Knowledge and the Biotechnology Economy: A Case of Mistaken Identity." Paper prepared for the High-Level Forum on Measuring Knowledge in Learning Economies and Societies, organized by Organisation for Economic Co-operation and Development in cooperation with NSF. May 17–18.